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Maritime route optimization

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Early attempt at route optimization

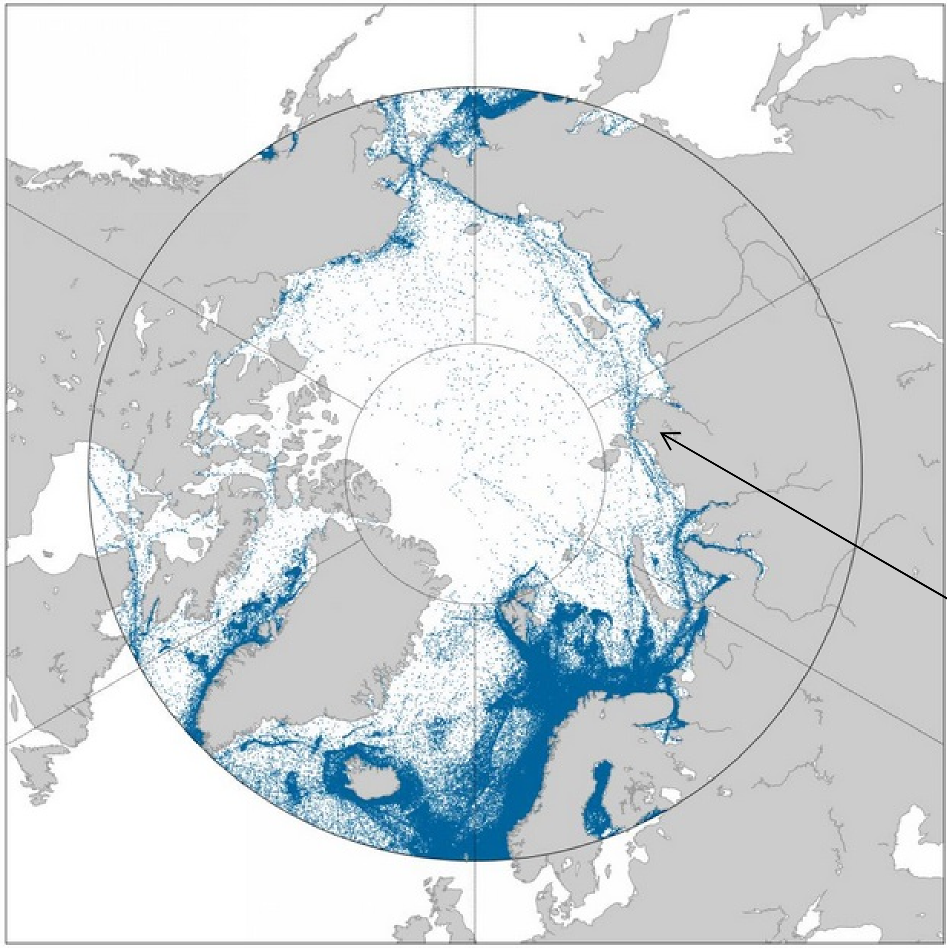
Jens Munk (1579-1628)

Tries to find a way to India through the North West Passage

Spends the winter 1619-20 in Hudson Bay.

Only 3 of his 64 men crew returns home.

Traffic in the Arctic region



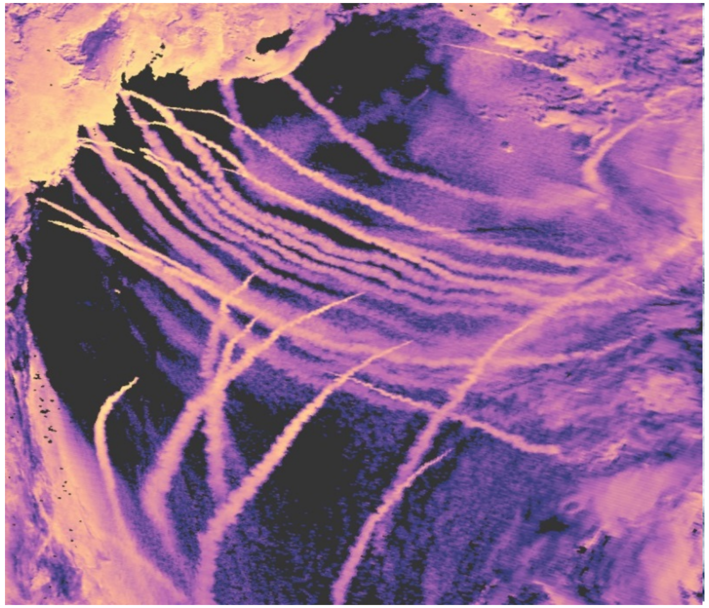
Marine traffic in the Arctic (2011/2012)

NE sea route:

46 vessels in 2012

BlueSIROS

- SIROS = Satellite Integrated Route Optimisation Service.
- “Near Real Time Marine Route Optimisation Service Integrating Satellite Derived Dynamic Ocean Currents”.
- Collaboration between DTU Space, DTU Transport, DHI, Danish Defence Centre for Operational Oceanography, and Danish Maritime Authority
- Application approved by ESA, 9 month Feasibility study (1 Dec 2015)
- Potential users involved:
  - Maersk Marine Technology
  - Norden
  - DFDS Seaways



March 4, 2009, northeast Pacific Ocean

Benefits of exploiting ocean currents

FIG. 173. — FRANKLIN'S CHART OF THE GULF STREAM.

Benjamin Franklin map of the Gulf Stream (1769)

Study objective

- Feasibility of an operational system for marine route optimisation, which integrates forecasts of ocean currents based on near-real time satellite altimetry data.
- Enabling shipping companies to minimize fuel consumption -> reduce air pollution and fuel costs.

15 years of seafaring experience using weather routing:

- Reduced fuel consumption by 6%
- Reduced ship rough weather damages by 73%
- Costs of maintenance by 29 %
- Cargo damage lawsuits by 87%
- Length of ship delays due to unfavourable weather by 80%

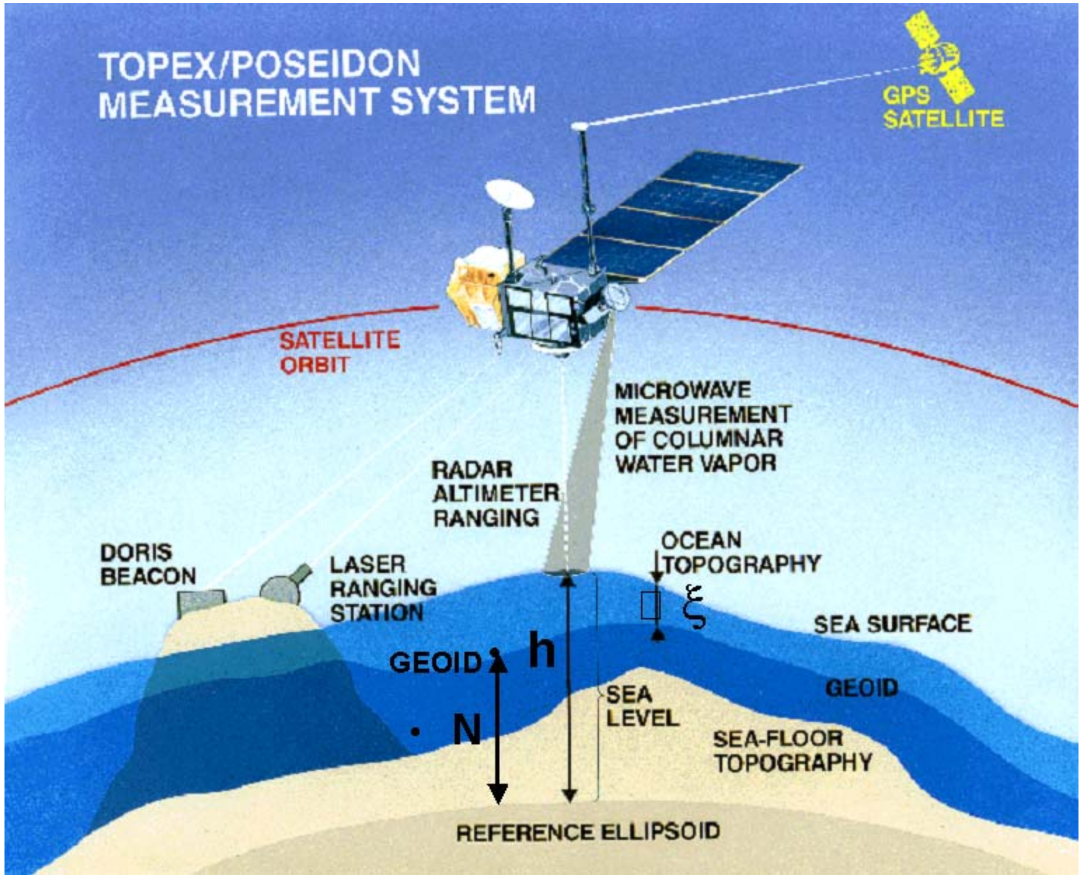
Altimetric Observations

Accurate radar (or laser) ranging to the sea surface based on accurate time-determination $d = t * c / 2$

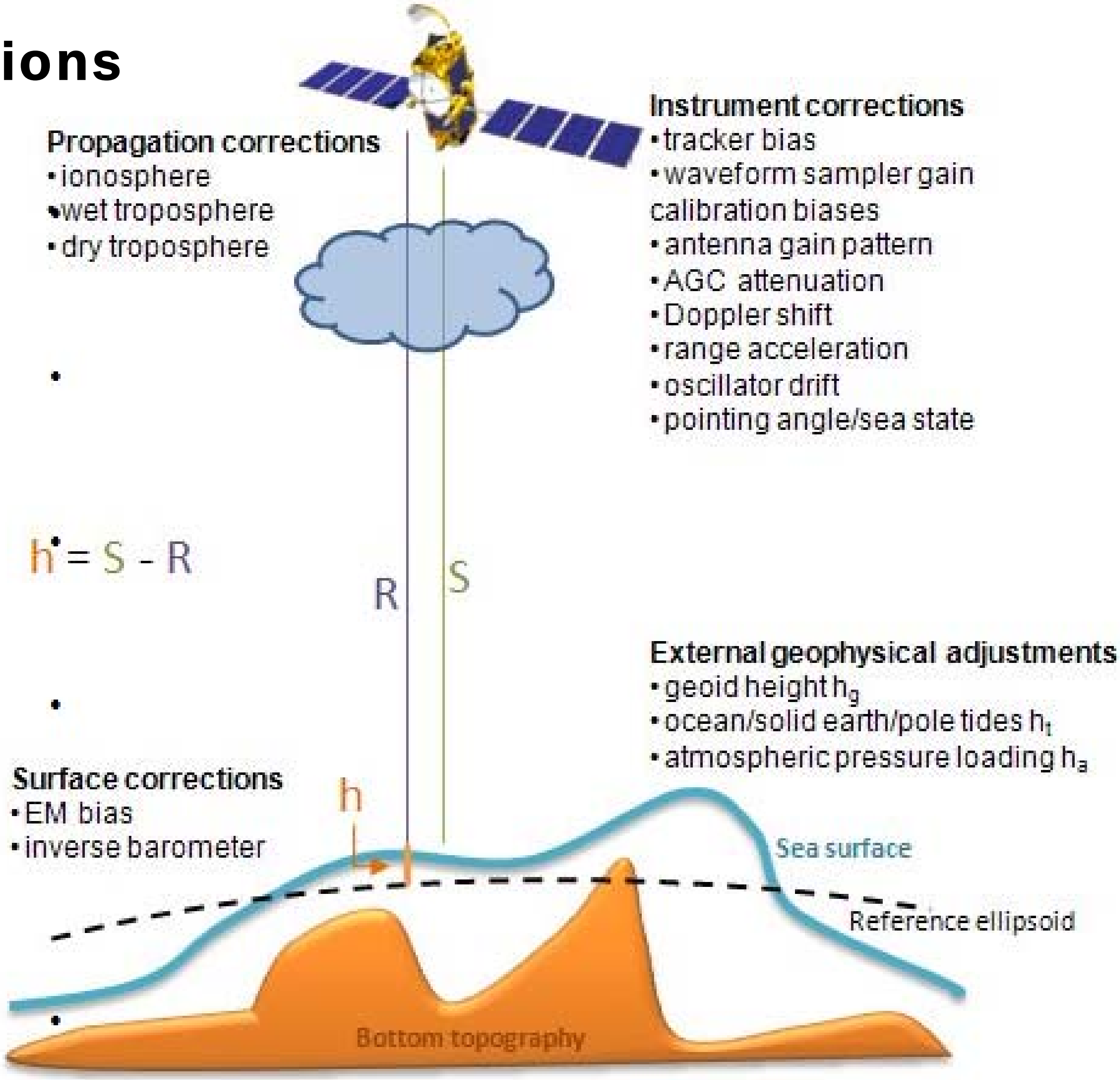
Where c must be adjusted slighly for propagation through ionosphere and troposphere.

$SSH = Height_{sat} – Range$

$Height_{sat}$ is determined using GPS

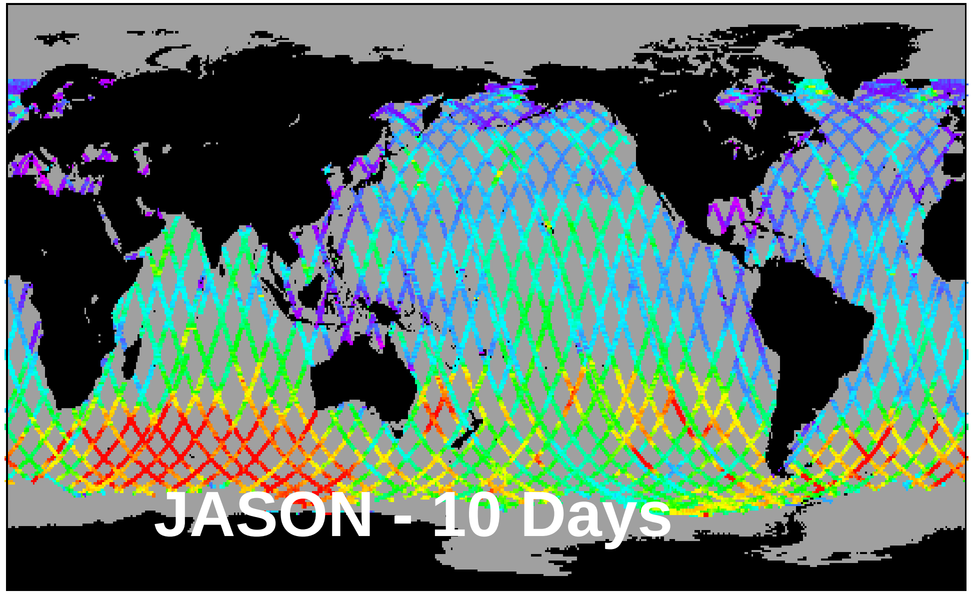


Corrections

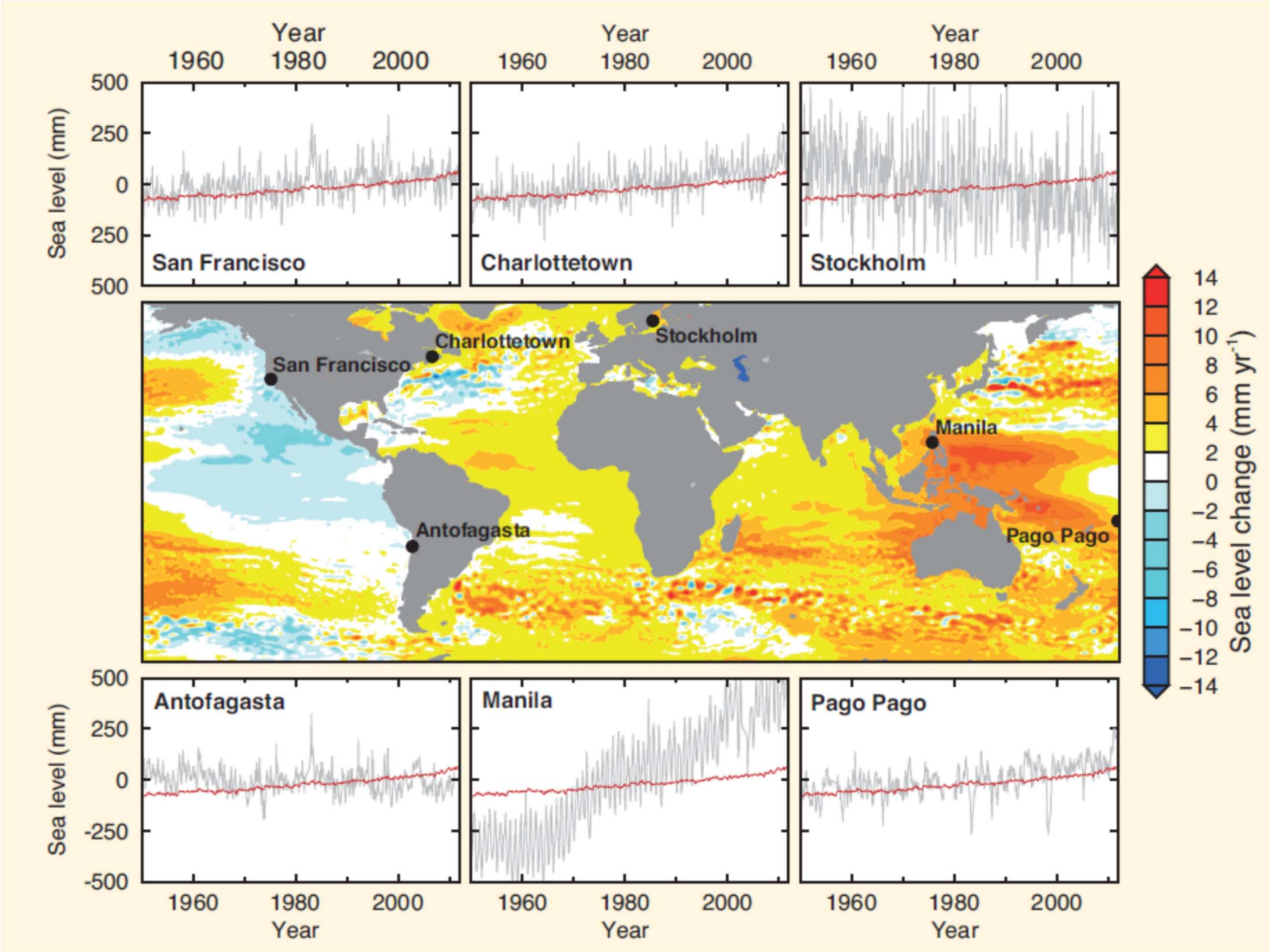


Orbit Parameters

Coverage of sea surface depends on the orbit parameters (inclination of the orbit plane and repeat period).



	Satellite	Repeat period	Track spacing	Inclination
Repeating (ERM)	Sentinel-3	30 days	95 km	98°
	JASON 1-2-3	10 days	315 km	66.5°
Geodetic	Cryosat-2	369 days	7 km	88°

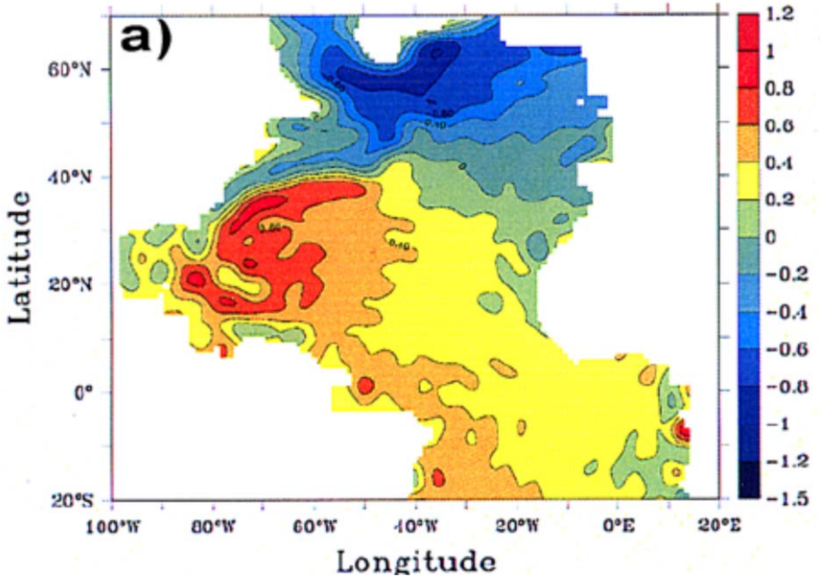


Year
1960
1980
2000
500
250
0
250
500
Sea level (mm)
San Francisco
Charlottetown
Stockholm
Antofagasta
Manila
Pago Pago
-250
-500
14
12
10
8
6
4
2
0
−2
−4
−6
−8
−10
−12
−14
Sea level change (mm yr^{-1})

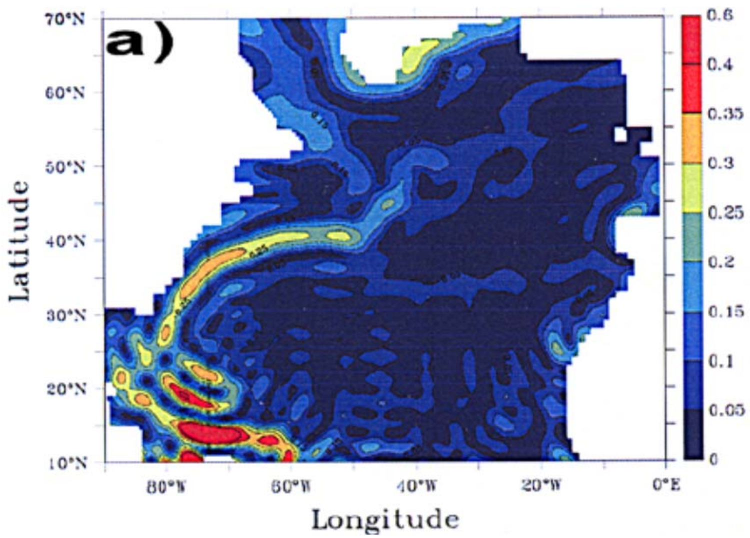
Ocean currents

- Satellite altimeter: determines sea surface relative to reference ellipsoid
- Shape of sea surface -> information on geoid and the ocean circulation
- Ocean at rest: surface = geoid (+/- 100 m around ellipsoid)
- Ocean moves: surface deviates from geoid (+/- 1 m)

  -> information on tides and surface currents
- Resolution limited by knowledge of the shape of the geoid

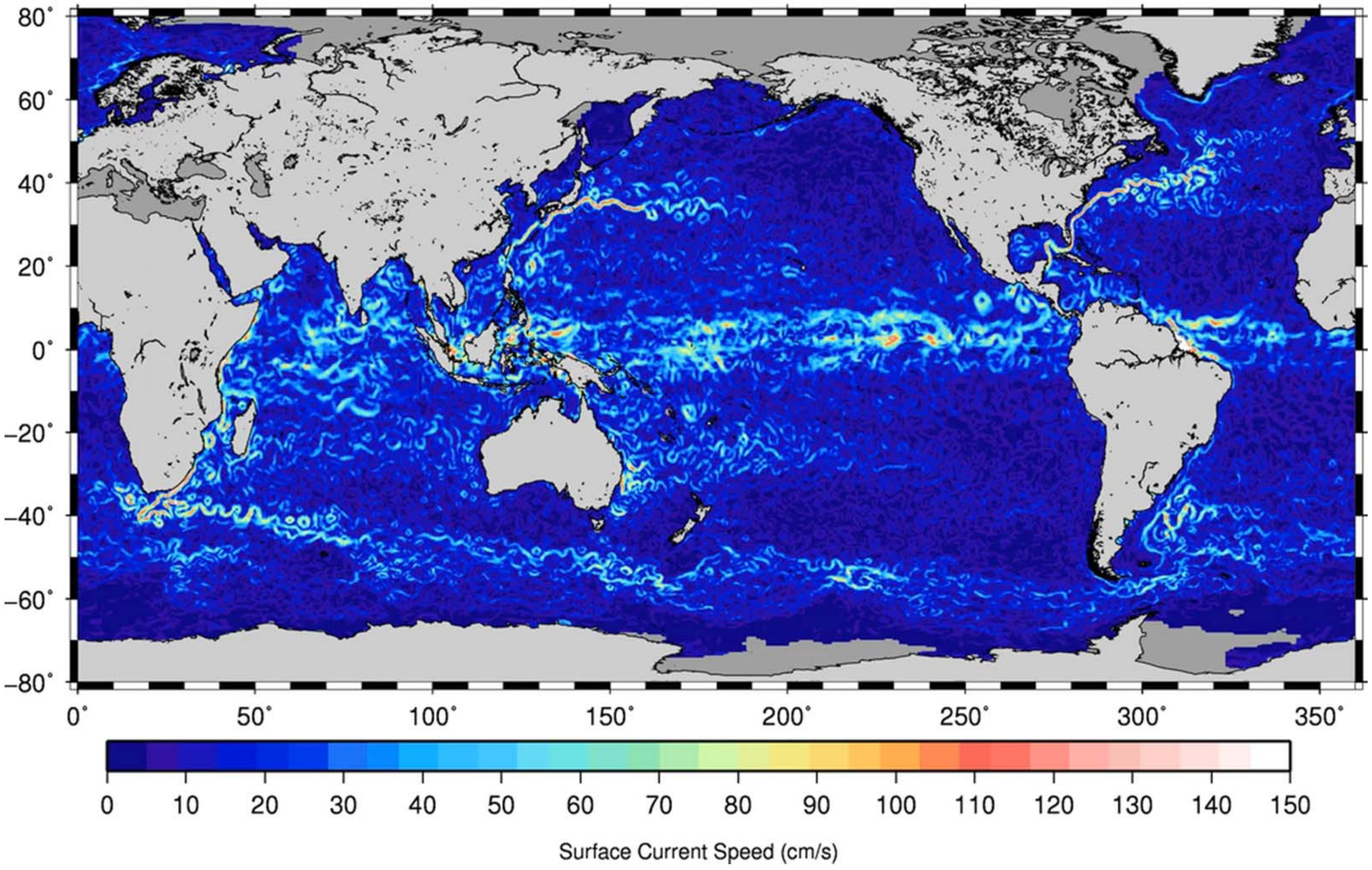


Topography (m)



Geostrophic currents (m/s)

12 30

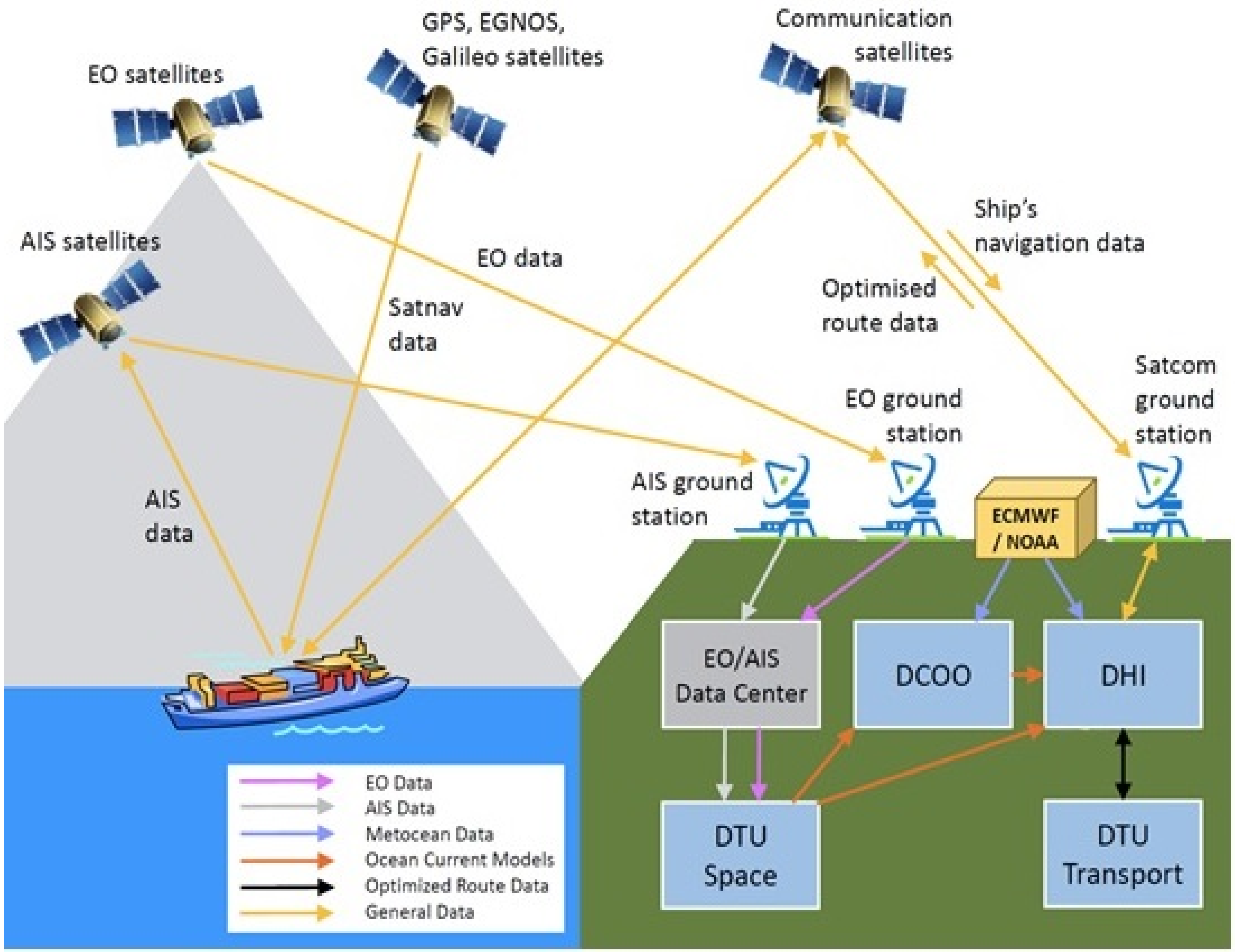

80˚
60˚
40˚
20˚
0˚
–20˚
–40˚
–60˚
–80˚
0˚
50˚
100˚
150˚
200˚
250˚
300˚
350˚
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
Surface Current Speed (cm/s)

Data + models available:

- Near real-time estimates of currents, wind speed, and wave height
- Integrate in standard ocean modelling and forecasts
- Newly developed vessel drift model for bulk carriers for both deep and shallow waters: predicts the ships' behaviour encountering wind, waves and currents (inputs: geometric and operational characteristics of the ship, stability and hydrostatic data, ship position)
- Estimated savings on trans-atlantic route (average speed of 16 knots):
  - 7.5% when riding favourable currents
  - 4.5% when avoiding unfavourable currents

Challenges in the Arctic Region

- General metocean data less accurate.
- Low inclination of the Jason-2 & -3 orbits ($\approx 66°$) preclude them covering the Arctic oceans. European Sentinels will be capable of providing EO information for marine route optimisation in the Arctic Ocean.
- Communication towards the ships has limited bandwidth, which restricts the amount of information that can be transmitted.
- Safety requirements for maritime traffic in the Arctic are higher
- Defence Centre for Operational Oceanography (DCOO) represents a user with requirements for optimisation of complex operations during adverse conditions such as search and rescue operations


GPS, EGNOS,
Galileo satellites
Communication
satellites
EO satellites
AIS satellites
EO data
Satnav
data
Ship's
navigation data
Optimised
route data
Satcom
ground
station
EO ground
station
AIS ground
station
AIS
data
ECMWF
/ NOAA
EO/AIS
Data Center
DCOO
DHI
DTU
Space
DTU
Transport
EO Data
AIS Data
Metocean Data
Ocean Current Models
Optimized Route Data
General Data